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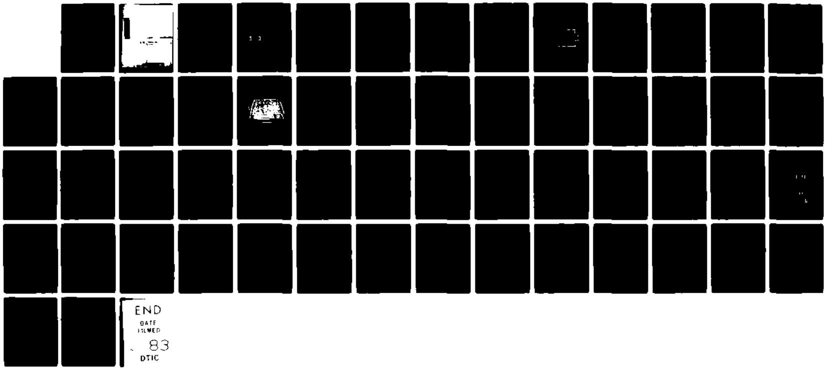

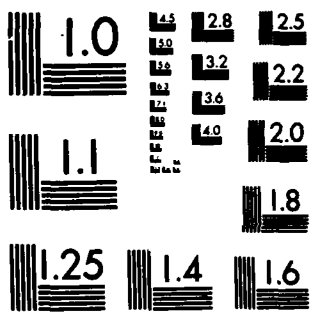
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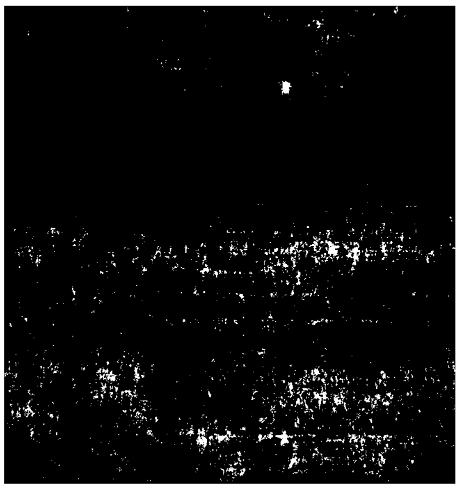

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This report reviews the background, objectives, methodology, and results of a research project devoted to (1) the development of principles and procedures relevant to the selection and training of sea/space mission personnel, (2) the investigation of preventive monitoring and corrective procedures to enhance sea/space mission performance effectiveness, and (3) the evaluation of countermeasures to the potentially disruptive effects of

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unfamiliar and stressful environments. Initial research endeavors were directed toward the design and construction of an experimental microsociety environment for continuous residence by small groups of volunteer participants over extended time periods under conditions that provide for performance and recreational opportunities within the context of a biologically and behaviorally supportive setting. Studies were then undertaken to analyze experimentally (1) conditions that sustain group cohesion and productivity and that prevent social fragmentation and individual performance deterioration, (2) motivational effects produced by the programmed consequences of individual and team performance requirements, and (3) behavioral and biological effects resulting from changes in group size and membership. The significance of these investigative undertakings is to be understood in terms of emergent environmental, motivational, and social-interaction principles having practical relevance for the establishment and maintenance of operational mission performance effectiveness.

# BEHAVIOR ANALYSIS OF CONFINED MICROSOCIETIES IN A PROGRAMMED ENVIRONMENT

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# Behavior Analysis of Confined Microsocieties in a Programmed Environment[1]

Requirements for high levels of human performance and adaptation within the isolated and stressful environments associated with many foreseeable sea-based (and spaceflight) missions necessitate the development of research-based technological procedures for maximizing the probability of effective functioning at all levels of personnel participation (Fraser, 1972; Brady, 1982; Cheston and Winter, 1980). Indeed, Russian social scientists have concluded that the only impediment to successful long-duration spaceflight missions is "psychological," referring to the need for the creation of a fundamental body of information from which principles and techniques can emerge to structure rationally the interactions between spaceflight participants and their physical and social environments (Samsonov, 1979). And of at least equal significance are the concerns expressed by American social scientists regarding the potential for untoward events within confined habitats that could result from underestimating the importance of a technology of human performance under such circumstances (e.g., Helmreich, Wilhelm, and Runge, 1980). Sea-based platforms and manned space habitats are truly isolated and confined social organizations, and they can thus be characterized as a "microsociety."

For the most part, analyses of individual and team performances under operational, training, and simulation conditions that emphasize brief or extended exposure of mission members to constant scenario or simulation environments have been somewhat limited by the constraints imposed on experimental interventions to identify critical causal factors. Furthermore, reviews and interpretations of the extensive literature in the area suggest that research on human performance effectiveness under conditions of isolation and confinement would be advantaged by the development and application of an effective methodology for extended-duration analyses of both the functional and topographic aspects of such situations under conditions that provide for operational task assessment and evaluation within the context of a comprehensive living and work setting (Thorndyke and Weiner, 1980; Hare, 1976).

Accordingly, in response to the growing recognition of the importance of developing technological guidelines related to (1) the impact of the type of mission, (2) the characteristics of crew participants, and (3) the skill level of a novitiate participant as they affect a crew's ability to accomplish mission objectives, a research project was undertaken to investigate performance effectiveness within the context of a laboratory environment in which both interpersonal and work behaviors can be continuously monitored and evaluated over extended time periods (e.g., days). Rather than simulating a targeted operational environment exhibiting a high degree of physical realism at the expense of flexibility of researchable problems to be addressed within such a setting, the present laboratory facility was designed to address a broad range of performance problems from the perspective of a functional or behavior analysis of performance effectiveness (Ferster and Perrot, 1968). This analysis emphasizes the assessment of relationships between antecedent conditions, performance effectiveness, and consequences that is afforded by the design features and measurement capabilities of such a "programmed environment."

This paper, then, reviews the experimental methodology and representative results derived from studies of individual and crew behavior that were jointly sponsored by the Office of Naval Research and the National Aeronautics and Space Administration. The research methodology includes a laboratory environment that was intentionally designed to facilitate the implementation of a "behavioral program" of activities that not only structures the crew's use of available resources but also provides the framework for the observation and measurement of a comprehensive range of behaviors. A discursive rationale and preliminary model have been presented elsewhere for the application of continuously programmed environments in human research on the basis of extended experimental control, objective recording, and the maintenance of realistic and naturalistic incentive conditions for the assessment of a broad range of individual behavioral processes (Findley, 1966).

## PROGRAMMED ENVIRONMENT

The residential laboratory consists of five rooms and an interconnecting corridor, and it was constructed within a wing of The Henry Phipps Psychiatric Clinic at The Johns Hopkins University School of Medicine. The floor plan of the laboratory and its position within the surrounding building shell are presented in Figure 1. Each private room (2.6 x 3.4 x 2.4 m) is similar to a small efficiency apartment

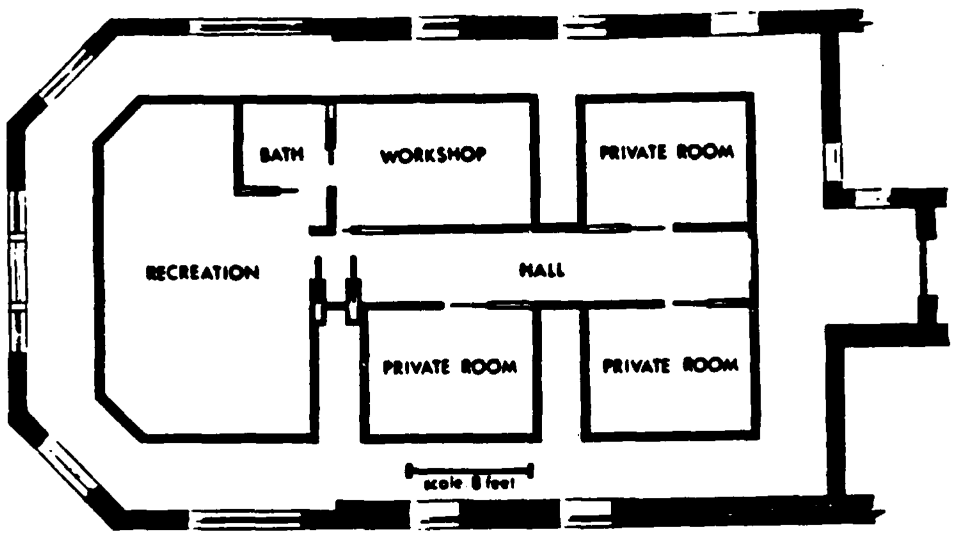



Figure 1. The floor plan of the laboratory and its position within the surrounding building shell.

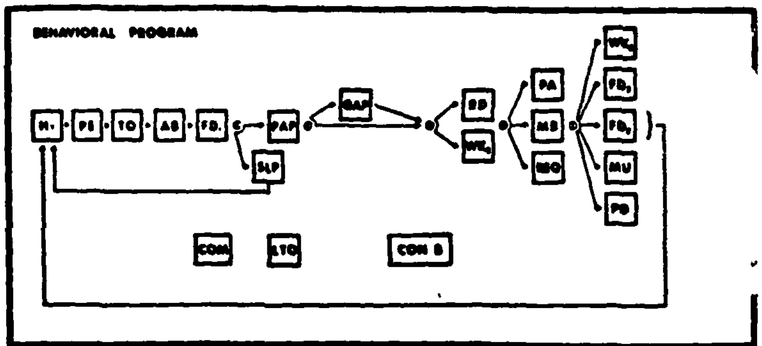
containing kitchen, bathroom, bed, desk, etc. The recreation area (4.3 x 6.7 x 2.7 m) contains a complete kitchen facility along with exercise equipment and games. The workshop (2.6 x 4.1 x 2.7 m) contains operator consoles for individual and crew performance tasks. A common bathroom serves the recreation and workshop areas. In summary, the programmed environment can accommodate at least three participants for intensive behavior analyses, and even more study subjects could be added to an experimental protocol by allowing additional members' temporary residence within the recreation area along with their periodic rotations to the privacy of the individual quarters when solitary members move to the recreation area. Design drawings and photographs of the laboratory have been published elsewhere (Bigelow, Brady, and Emurian, 1975; Brady, Bigelow, Emurian, and Williams, 1975; Emurian, Brady, Ray, Meyerhoff, and Mougey, in press).

The laboratory is "programmed" in the sense that its resources are restricted by design features that electronically regulate access to storage compartments or to areas containing supplies necessary to accomplish a given performance unit. Electro-mechanical control devices positioned throughout the environment are interfaced with computer systems located within adjoining laboratory support facilities that provide for monitoring, programming, recording, and data analysis. Audio and video equipment, located with the awareness of participants within each of the residential chambers, permits continuous monitoring during conduct of an experiment. Ample privacy exists, however, for personal hygiene and sleeping.

## BEHAVIORAL PROGRAM

To structure the micronauts' use of the laboratory's resources in a disciplined yet meaningful way, a behavioral program was developed to establish and maintain individual and crew performance baselines as well as to provide the context for experimental manipulations of performance interactions during extended residential missions. A behavioral program is defined by (1) an array of activities or behavioral units and (2) the rules governing the relationships between these activities. Figure 2, for example, illustrates diagrammatically (1) the fixed and optional activity sequences that characterize a typical behavioral program used to establish baseline performances and (2) an array or inventory of component activities that constitutes such a program. Each box within the diagram represents a distinct behavioral unit and performance requirement, with progression through the various activities programmed sequentially from left to right. Finally, all behavioral units are scheduled on a contingent basis such that access to a succeeding activity depends upon satisfaction of the requirements for the preceding unit.

Beginning at the far left of the diagram, the fixed activity sequence is composed of all activities between and including Health Check (H✓) and Food One (FD1). The Health Check activity requires the subject to determine his temperature, pulse, and weight and to complete several status quesionnaires regarding his mood and reactions to the laboratory environment. He then completes the following activities in the order displayed: Physical Exercise (PE), requiring 300 correct responses on an




**INVENTORY OF ACTIVITIES**

| NOTATION | FULL NAME | BRIEF DESCRIPTION |
|---|---|---|
| H✓ | HEALTH CHECK | TEMPERATURE, PULSE, WEIGHT, STATUS REPORT |
| PE | PHYSICAL EXERCISE | 300 CORRECT PRESSES ON AUTOMATED TASK |
| TO | TOILET OPERATIONS | USE OF PRIVATE BATHROOM AND CONTENTS OF DRAWER CONTAINING TOILETRIES |
| AB | AUTOGENIC BEHAVIOR | RELAXATION EXERCISES ON CASSETTE TAPE |
| FD1 | FOOD ONE | TWO SELECTIONS FROM A LIST OF LIGHT FOODS |
| SLP | SLEEP | USE OF BED AND PRIVACY CURTAIN |
| PAP | PRIVATE ARITHMETIC PROBLEMS | 180 CORRECT SOLUTIONS OF ARITHMETIC PROBLEMS |
| GAP | GROUP ARITHMETIC PROBLEMS | OPTIONAL, CONTRIBUTE CORRECT SOLUTIONS OF PROBLEMS TO GROUP RATIO CRITERION |
| RD | READING | ACCESS TO BOOK |
| WK2 | WORK TWO | PROBLEMS, EXPERIMENTS, ASSEMBLY PROJECTS |
| PA | PUZZLE ASSEMBLY | ASSEMBLE A PUZZLE |
| MB | MANUAL BEHAVIOR | ACCESS TO ART MATERIALS |
| REQ | REQUISITION | EARN DELAYED DELIVERY OF TREATS |
| WK3 | WORK THREE | ACCESS TO WORKSHOP |
| FD2 | FOOD TWO | PRIVATE MAJOR MEAL |
| FD3 | FOOD THREE | MAJOR MEAL IN RECREATION ROOM, GAMES |
| MU | MUSIC | EARN A CASSETTE TAPE |
| PG | PRIVATE GAMES | ACCESS TO SOLITARY GAMES |
| COM | COMMUNICATION | ACCESS TO INTERCOM |
| LTO | LIMITED TOILET OPERATIONS | ACCESS TO ESSENTIAL TOILET FACILITIES |
| CON B | CONDITION B | CHANGE IN PROGRAM CONDITION |

Figure 2. A diagrammatic representation of the fixed and optional activity sequences that characterize a typical behavioral program used to establish baseline performances along with an array or inventory of component activities that constitutes such a program. (Reprinted from Emurian, Emurian, and Brady, 1978.)

automated exercise task; Toilet Operations (TO), providing access to the private room bathroom and shower; Autogenic Behavior (AB), in which the subject follows taped relaxation instructions; and Food One (FD1), in which the subject is permitted to select two items from a presented list of 10 "light" foods such as coffee, soup, cereal, etc.

When Food One is completed, the subject is eligible to select one of the following two activities: Private Arithmetic Problems (PAP), requiring 150 solutions of problems presented on a CRT, or Sleep (SLP), providing access to the bed for an unlimited time period of at least 30 minutes. If the subject selects Sleep, he is required to return to the Health Check activity and the fixed activity sequence at the completion of Sleep. This is indicated by the broken line originating at Sleep and terminating at Health Check. In summary, then, the fixed activity sequence was designed to maintain and assess the subject's health if he were otherwise indisposed to engage in the broader selection of opportunities.

The optional activity sequence begins with the choice of Private Arithmetic Problems instead of Sleep. At the completion of that activity, the subject is eligible to select Group Arithmetic Problems (GAP), in which a subject can contribute to a performance criterion that must be satisfied before the group can enter the recreation area. Group Arithmetic Problems can be skipped, however, allowing the choice between one of the following two activities: Reading (RD), providing at least 30 minutes' access to books contained in a drawer, or Work Two (WK2), in which the subject completes in private various problems, experiments, or assembly projects presented in a drawer. When the selected activity is completed, the subject is eligible to select one of the following three activities: Puzzle Assembly (PA), requiring the subject to assemble a jigsaw puzzle presented in a drawer, Manual Behavior (MB), providing at least 30 minutes' access to art supplies contained in a drawer, or Requisition (REQ), allowing the subject to operate a manual task to earn points that are exchangeable for special privileges. On completion of the selected activity, the subject is eligible to select one of the following five activities: Work Three (WK3), providing access to the workshop, Food Two (FD2), requiring at least 30 minutes and providing the subject with a major meal to prepare and consume within his private room, Food Three (FD3), providing at least 30 minutes in the recreation room by all subjects together, Music (MU), allowing the subject to earn a cassette tape that can be played at any time, or Private Games (PG), allowing at least 30 minutes' access to an assortment of solitary games within a drawer. As indicated by the broken line, once a subject completes his choice among those five activities, he returns to Health Check and resumes the fixed activity sequence. In summary, then, the optional activity sequence allows the subject flexibility in the selection and arrangement of activities, both individual and social.

At the bottom of the diagram are two activities having different selection rules. The Limited Toilet Operations (LTO) activity, which provides access to the bathroom but not the shower, can be selected at any time. The Communication (COM) activity allows access to the intercom for intersubject communications. A subject is usually permitted to use the intercom to converse with other participants only if he is between any two adjacent activities within the behavioral program. Although the Communication activity is available between any two activities, a conversation requires at least two subjects' simultaneous presence within the Communication activity. Conversing subjects, however, can be located at different sequential positions within the behavioral program. For example, a Communication and conversation might occur when one subject is between Autogenic Behavior and Food One, and another subject is between Manual Behavior and the last column of activities, and so on.

If communications are required between the participants and the experimenters, messages may be transmitted to a CRT located within each private room. A manual of instructions detailing the program and use of environmental resources is contained in each room of the laboratory. Examples of a participant's instructional manual, an operator's manual, health assessment questionnaires, and procedural details associated with the content, management, and measurement of various activities have been presented elsewhere (Emurian, Emurian, Schmier, and Brady, 1979).

The behavioral program provides a promising solution to the problem of how to structure the resources available to a confined microsociety. The functional interdependencies among activities ensure that performances of value to the welfare of the individual (e.g., physical exercise), to the welfare of the crew (e.g., social recreation), and to the welfare of a "mission" (e.g., sustained performance effectiveness) occur recurrently over time. These functional interdependencies reflect the "motivational" properties inherent within successive progressions through the program, and all incentives to maintain the overall operational status of the microsociety can reside within the behavioral schedule itself.

Important advantages of the behavioral program in maintaining such performances include its independence of a given participant's idiosyncratic reinforcement history in relationship to activity preferences that might serve as reinforcers within more delimited, albeit quantitatively rigorous, response-reinforcer contingencies (cf., Bernstein and Ebbesen, 1978; Premack, 1965). It is reasonable to suggest, however, that the design of microsocieties for more extended periods of confinement than those to be discussed herein would be advantaged by a quantitative model of reinforcement strength that would encompass individual variability and shifting reinforcer "value" over time. Such a model would be anticipated to increase the technical precision of the structure of behavioral program activities and their associated parameters.

Not only does the behavioral program structure access to resources, but it also makes available for measurement all corresponding activity units. The boundaries between successive activities in the program impose rigor on the assessment of individual and group preferences and effectiveness within those activities. Additionally, the program has the advantage of providing a comprehensive range of variables for observation and measurement. For example, at one level, a subject's performance on arithmetic calculations could be assessed (e.g., errors, response latency), and at another level, a subject's frequency and duration of progressions through the program could be assessed without regard to the intensive analysis of component activities composing such progressions. Moreover, the social status of the microsociety may be assessed by observing the degree of "synchrony" among subjects in the selection and completion of similar activities at the same time. Observations of subjects' communication networks along with the frequency, duration, and quality of dyadic and triadic social episodes would complement synchrony measures. All these factors, then, contribute to a method having considerable and demonstrated power in the analysis of variables that impact upon individual and crew performances, especially with regard to the potential interrelationships between the effectiveness of such performances and other contextual aspects encompassing the work environment.

Activities and performance requirements can easily be added to and withdrawn from the behavioral program. For example, it was desired to replace arithmetic calculations with a Multiple Task Performance Battery (MTPB) as a measure of complex human performance. A comprehensive description of the performance battery has been published by Emurian (1978), and a rationale for this "synthetic work" methodology has been provided by Morgan and Alluisi (1972). As displayed in Figure 3, the MTPB is composed of the following five subtasks that are presented simultaneously to an individual operator: (1) oscillating lights, providing a measure of watchkeeping, (2) warning lights, providing a measure of vigilance, (3) probability monitoring, providing a measure of attentive functions, (4) pattern identification, providing a measure of sensory-perceptual functions, and (5) arithmetic calculations, providing a

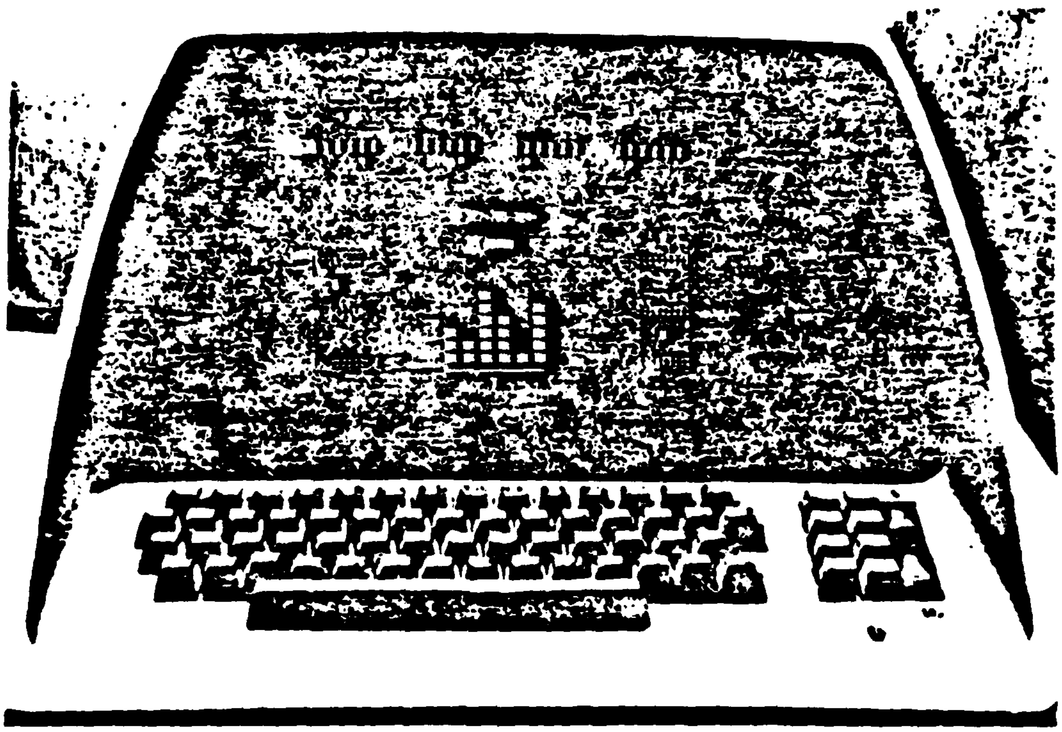


Figure 3. A photograph of the CRT console displaying the five subtasks composing the Multiple Task Performance Battery (MTPB). (Reprinted from Emurian, Emurian, and Brady, 1982.)

measure of computational functions. Accurate operation of the subtasks produces "accuracy points" that are cumulatively displayed on the CRT. To "build" this task into the behavioral program, a CRT console was located in the workshop such that only one participant could perform the task at a time, and access to the workshop was made available between any two adjacent activities in the program. When a participant completed a work period in the workshop, he would return to his private quarters and resume the behavioral program at the point of departure. Private Arithmetic Problems and GAP were simply withdrawn from the inventory of activities.

Although performance effectiveness on the MTPB could be made contingently related to access to other "high-value" activities in the program similar to PAP within Figure 1, a different incentive could be applied by relating performance effectiveness to a subject's compensation, and this has been the approach used for recent investigations in the laboratory. Thus, the intrinsic motivational properties of the behavioral program provide the context in which external incentives can be applied where a direct moment-to-moment relationship is desired between performance effectiveness (e.g., quality and quantity) and its immediate consequence. Such an interplay between incentives can be dramatically effective in (1) generating and sustaining complex human performances over extended time periods and in (2) providing the ancillary contextual observations that make performance changes interpretable in terms of a functional analysis.

Subjects respond favorably to the programmed environment and to the behavioral program. With notable exceptions, subjects report a sense of heightened accomplishment and productivity in the use of their time while following the program. Although clocks are present in each room of the laboratory, the behavioral program is not oriented to specific time markers, and subjects may drift in wake-sleep cycles according to their personal dispositions. If sleep discipline is required, however, the program could anchor the Sleep activity to a particular time window (e.g., 2300-0600 hours), and remaining time would be filled with programmed activities other than Sleep. Such a procedure has been used successfully in an investigation that required subjects' circadian rhythms to be held constant (Emurian, Brady, Meyerhoff, and Mougey, 1981).

Well over 150 male and female volunteers have participated in the research program to date, and only three subjects have withdrawn from an experiment before its scheduled completion. Almost all participants have a college background, and many are graduates. Acceptance into the research program follows psychological evaluation and detailed orientations to the laboratory and to the behavioral program. The research involves no elements of deception, and informed consent is an integral component of the orientation. Unless otherwise noted, the research results to be summarized herein were based upon analyses of three-man groups.

## HABITABILITY AND PACING STUDIES

Initially, preliminary habitability and performance programming evaluations (Brady, et al., 1975) were conducted with groups of two and three participants during 2- to 16-day intervals of continuous residence within the programmed environment. Only minimal (and basically biological) activity sequences (i.e., eating, sleeping, group recreation, etc.) were required during the briefer exploratory periods. More complex programmatic sequencing of activities was introduced across successive groups, with gradual extensions of continuous residential periods from 1 to 3, and then to 16 days.

In a typical 2-person experiment in this series (Emurian, Bigelow, Brady, and Emurian, 1975), two participants spent 50-65% of their wake time engaging in dyadic social activities, programmed in the recreation area, across a 10-day observational period. Additionally, a high degree of intersubject program synchrony was evidenced by the percentage of an experimental day (i.e., 24 hours) that the two subjects were engaged in identical individual activities or were simultaneously engaged in different individual activities within the same column of optional activities (60-90% synchrony). Analysis of wake-sleep patterns, reported in Brady and Emurian (1979), showed a progressive increase in the duration of successive wake periods with no evidence of systematic changes in the duration of successive sleep intervals. This resulted in a complete 12-hour reversal of the wake-sleep cycle over the residential study period.

These preliminary studies showed that small groups could be maintained under stress-free living conditions for up to 16 days of continuous residences in the programmed environment. Additionally, the sequential contingency performance program developed throughout the course of these investigations was supportive of both individual and social productivity under conditions of isolation and confinement.

Based upon the behavioral program that was developed and operationally proven throughout the preceding investigations, a program parameter analysis was undertaken to determine the sensitivity of the behavioral program to experimental interventions (Brady, et al., 1975). Of particular interest were the effects of temporal and social factors on group performance, and an experiment was designed to assess variations in the rate of progression between behavioral units as they may influence social activities and time spent within other performance units. The design of the environment and behavioral program permitted experimental manipulation of such temporal factors by controlling the interval required to elapse between the termination of one behavioral unit and the initiation of the succeeding activity. Under such conditions, it was possible to permit "free pacing" by the participants or to program a delay or "pause" requirement between behavioral units during which no activities or environmental facilities were available. The effects of the pause and free-pacing conditions were evaluated during 6-day and 10-day experiments with several successive days under each of the two conditions.

The effects of the pause procedure in slowing the temporal progression between behavioral activities was evidenced by increased program cycle durations (*i.e.*, the time elapsed from the initiation of Health Check through the completion of the last optional activity), with the delay duration subtracted from such determinations. In two study groups, these effects were attributable to increases in the durations of social activities, whereas in the third group, increases in activity durations occurred throughout the behavioral program. Taken together, however, these results indicated the sensitivity of the behavioral program to experimental "treatments," and they emphasized the importance of social activities as reinforcers for groups residing under conditions of isolation and confinement.

## GROUP COHESION STUDIES

The major findings of the preceding analyses emphasized the differential importance of specific programmed activities (*e.g.*, social interaction) in maintaining individual and group performances, and they demonstrated the sensitivity of such baseline behaviors to experimental interventions (*e.g.*, program condition changes and reversals) over the course of extended residential periods. Consequently, a series of studies was undertaken to focus upon the motivational and emotional effects of varying social interaction conditions in five groups of three participants for 10 to 15 days (Emurian, Emurian, Bigelow, and Brady, 1976).

A cooperation condition was in effect when all three participants were required to select access to a group area (*i.e.*, recreation room and workshop) together before it became available for occupancy. That is, participants were required to enter and leave a group area at the same time. In contrast, a non-cooperation condition was in effect when a group area was accessible singly, without regard to the other participants' activity selections. The effects of these two social interaction contingencies were evaluated in various orders and durations of conditions across the five groups.

The cooperation and non-cooperation contingencies differentially affected the status of the confined microsocieties. The effects of such contingency management procedures were discerned not only by the social behavior of the group but also by collateral individual behaviors that characterized performances within the programmed environment. Enhanced levels of intersubject program synchronization and intercom frequencies were accompanied by comparable increases in the magnitude of triadic social episodes during the cooperation condition. The percent of total time spent in triadic social episodes and the increased durations of such episodes, combined with corresponding social interaction measures, suggested a potentially important consequence of cooperation contingencies in maintaining more durable social interactions when continued access to the group areas accrued primarily as a result of the frequency of social interactions.

The impact of cooperation contingencies on a confined microsociety would seem to be of particular significance when considered in light of group fragmentation effects that occurred during non-cooperation conditions. Under those conditions, the distribution of dyadic percent times into two "high-pairing" participants and one "low-pairing" participant within the groups suggested the development of a two-person ingroup and a relative social isolate during the non-cooperation condition. And the extent to which motivational and emotional interactions participated in the cooperation contingency effects was suggested by the first group when the change from cooperation to non-cooperation conditions occurred. Within minutes after the condition change was introduced during the course of a triadic social episode at the end of Day 4, Subject 2 became involved in a verbal altercation with the other two participants, and he abruptly left the group area alone, which was permissible under the non-cooperation condition. Throughout the ensuing three days of the non-cooperation condition, Subjects 1 and 3 continued to engage in frequent dyadic social interactions that excluded Subject 2. More importantly, the error rate reflected in Subject 2's "private arithmetic" performances increased dramatically, as shown in Figure 4, during the period immediately following the disruptive emotional interaction (i.e., arithmetic activities 14, 15, and 16). The interacting motivational effects of delayed progress through the program can, however, be presumed operative in the equally significant decrease in error rate that occurred even before termination of the non-cooperation condition (i.e., arithmetic activities 17 and 18).

In summary, these analyses showed that cooperation contingencies, which required coördination among group members before access to a group area was granted, embedded within the behavioral program, counteracted the tendency for a three-person microsociety to fragment over time. Such contingencies prevented persons with little interest in interacting socially from becoming isolated from a group and, in at least one case,

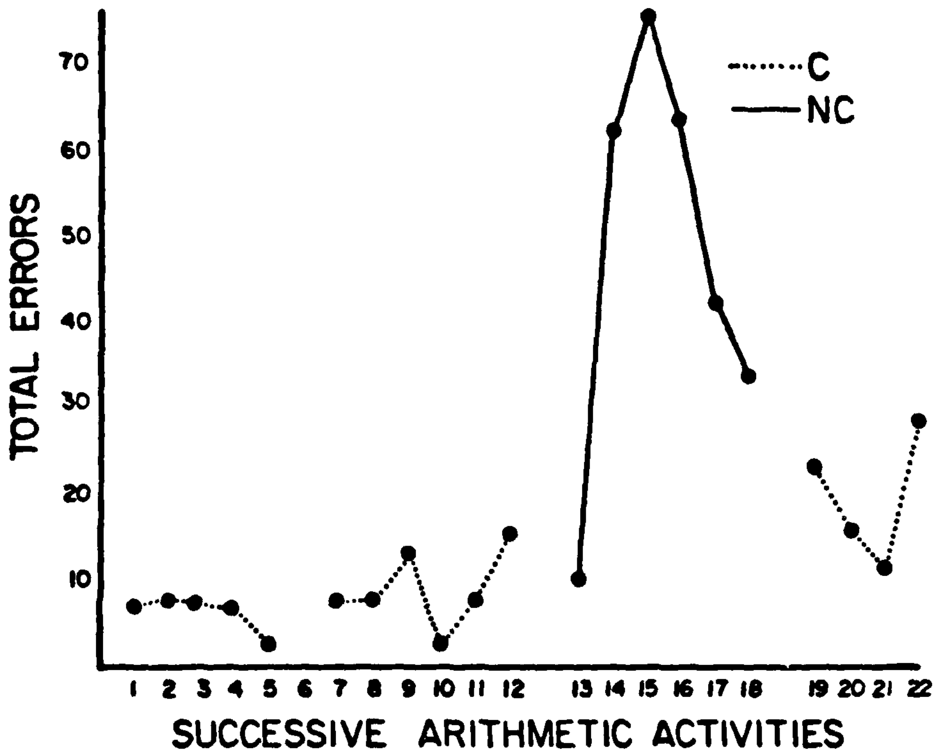



Figure 4. Total errors committed by Subject 2 on an arithmetic task, requiring 100 correct solutions to complete, across successive selections of the arithmetic task activity. Activity #6 was aborted because of equipment failure. C = cooperation condition, NC = non-cooperation condition. (Reprinted from Brady and Emurian, 1979.)

from showing a decline in individual performance effectiveness.

A more extended analysis of social contingency effects was undertaken with four additional 3-person groups that participated in a series of 10-day experiments to evaluate further the effects of subject pairing on individual and social behavior (Emurian, Emurian, and Brady, 1978). In addition to the triadic cooperation contingencies studied previously, dyadic cooperation contingencies were scheduled when simultaneous occupancy of a group area was permitted to any combination of two, and only two, participants. Solitary access to group areas also was permitted to parcel out the reinforcing effects of social episodes, independent of those attributable to the accessibility of a large space. As in the previous series of studies, the effects of the triadic and dyadic cooperation contingencies were evaluated in various orders of conditions across the four groups.

The results of this investigation showed that the status of a closed 3-person social system changed when social opportunities were limited to dyads as compared to the triad. Under such dyadic conditions, durations of social episodes were briefer in comparison to those observed under triadic conditions, and performance schedules drifted apart as reflected by decreased levels of harmony in the selection and completion of behavioral program activities. Additionally, daily response outputs on a task having social consequences were more often omitted during dyadic conditions. These results illustrated the group fragmentation effects previously observed during a non-cooperation condition in a situation in which triadic social interactions were prohibited, rather than being optionally available. Finally, the interaction between environmental contingencies and participants' dispositions to socialize was further demonstrated by the fact that three of the four groups had a lone member who failed to exhibit social behavior for several successive days under dyadic conditions.

Taken together, these group cohesion analyses indicated that low group cohesiveness increased members' vulnerability to social fragmentation in the absence of specifically programmed triadic contingencies of reinforcement that had the effect of promoting and sustaining productive social interactions among the inhabitants of a confined microsociety.

## INCENTIVE EFFECTS

Whereas the preceding investigations were undertaken with incentives inherent within the behavioral program in that participants received a per diem allowance, the next series of four experiments introduced the interplay between incentives both internal and external to the program as the means of motivating individual and group behavior. Three experiments were conducted with male groups, and one experiment was conducted with a female group. These studies were designed to develop a laboratory model that would allow systematic exploration of individual and social by-products of avoidance incentive conditions. The purpose of these experiments was to show how the interaction between "ground control" and the inhabitants of a confined microsociety, operationalized by programmed changes in the consequences of work, could affect the operational status and well-being of such a social system.

The first three 10- to 12-day experiments conducted in this series (Brady and Emurian, 1979) incorporated a "work unit" (i.e., one unit = 100 arithmetic problems, 1000 lever operations, and physical exercise) completion contingency determining the amount of group remuneration for participation in the study. Access to a work unit was optionally available between any two sequentially adjacent activities within the behavioral program. The consequences of completing a work unit were systematically varied to assess the effects of alternate performance-incentive relationships that were under the control of the experimenters.

Throughout the initial four days of the first experiment, for example, a "positive" (i.e., appetitive) relationship was in effect whereby completion of a work unit by an individual participant incremented a group account that was divided evenly among the participants at the conclusion of the experiment. Throughout the next four days of the experiment, a "negative" (i.e., avoidance) relationship was in effect such that work units no longer produced increments in the group account, but rather were required of the participants in order to avoid withdrawals of similar magnitude. That is, work performance requirements for Days 5 through 8 provided that a withdrawal be made from the group account for each uncompleted work sequence below an assigned daily total (e.g., 20) determined on the basis of group productivity during preceding appetitive days. This group requirement could be satisfied under any conditions of individual work scheduling or distribution decided upon by the group participants. The last two days of the experiment, Days 9 and 10, were programmed as a return to the conditions in effect during the first four appetitive days.

Such incentive conditions were chosen for investigation because of the evidence linking (1) hostility and aggression with aversive control (e.g., Hutchinson, 1976) and (2) dissipation of hostility to cooperative goals pursued under appetitive circumstances (e.g., Sherif, 1967; Deutsch, 1963). Although participants were aware of the two incentive conditions, they were not told in advance the order and duration of conditions that would be presented.

Detailed results of the first three experiments are presented elsewhere (Emurian and Brady, 1979). In summary, when participants' work was programmed according to the negative reinforcement schedule (i.e., avoidance of monetary loss), negative ratings of the behavioral program and of the experimenters were significantly higher during avoidance days in comparison to such ratings during appetitive days, and liberal unsavory invective was endured by research supervisors. Indeed, an extreme instance of such hostility was exemplified by one participant who deliberately and openly damaged some of the laboratory's furnishings. Additionally, the total number of work units completed each day by a group was more evenly distributed among the three participants during avoidance days than during corresponding appetitive days. In this latter regard, in a group where one member's work output was consistently somewhat less than the other two members, negative interpersonal ratings were directed toward the "low-productivity" person during the avoidance condition, and he was isolated from social activities during the final days of the study.

Finally, most group members reported dysphoric mood under the avoidance work condition.

In contrast to such effects observed under the avoidance schedule, when identical work was programmed according to a cooperative appetitive reinforcement schedule (i.e., monetary earnings), group members were free from disruptive by-products of the aversive schedule even when extraordinary work productivity was observed. These findings together suggest that the functional properties (i.e., consequences) associated with work were far more significant to the group members' well-being than were the topographical properties (i.e., the behaviors required to perform the work).

The fourth experiment completed within this series was even more revealing in that some group members undertook a sitdown strike with respect to work, after reacting for several days in ways that appeared parallel to crew reactions preceding the strike that occurred aboard the third Skylab mission (Emurian, Emurian, and Brady, 1982). This systematic replication of the previous experiments involved the introduction of the MTPB determining work performance within a duty station that could be occupied by subjects one at a time on a self-determined rotational basis, and it accordingly simulated situations requiring a crew to be continuously vigilant with respect to critical mission demands.

An example of one of the more extreme effects of avoidance incentive conditions was reflected in the performance data of this fourth investigation. After two initial days under appetitive incentive conditions, the three-person group was assigned an MTPB avoidance criterion of 12,000 points to accomplish on each of Days 3-5. Mission members informally agreed to distribute the criterion evenly among themselves. At the conclusion of Day 4, however, Subect 3 fell behind in his share of work, and he caused the criterion to be missed by 56 points. Unlike a high-productivity participant's tolerance of variation in work output during the appetitive condition, one of the other group members (Subject 1) became openly hostile at this relatively trivial shortcoming, and he reprimanded Subject 3 during an intercom conversation at the end of Day 4. Significantly, Subject 1 refused to perform any further work during the avoidance condition, whose duration was not known by the group, and on Day 5 the group lost heavily in potential earnings as a result, at least in part, of insufficient personnel to operate the MTPB on a sustained basis. Of at least equal importance was the fact that Subject 1's emotional outburst and his refusal to work was, in part, paralleled by Subject 2 who showed a markedly diminished output of work on Day 5. Neither Subject 2 nor Subject 3 showed a compensatory increase in work productivity on Day 5 that may have otherwise satisfied the criterion that was missed on that day by 6495 points. When the appetitive condition was reintroduced on Day 6, however, Subjects 1 and 2 again contributed to work output, and, indeed, all participants showed the greatest daily point accumulations on that final day of the experiment.

In summary, comparisons between incentive conditions on several behavioral program measures emphasized the deleterious effects of the avoidance incentive condition. Disruptive by-products of that condition included (1) interpersonal confrontation and antagonism, especially by high-productivity participants toward low-productivity participants, (2) vociferous written and spoken complaints about the schedule, (3) written and spoken hostility directed toward the experimenters, and (4) dysphoric feelings. And the results from the fourth group suggested that under avoidance incentive conditions where performance requirements are continuous and challenging (e.g., MTPB), a crew may fail to complete its mission (i.e., completion of assigned work). In contrast, under appetitive incentive conditions, such disruptive effects did not occur even when extraordinary performance productivity was observed, and a several-day history of negative effects could be overcome by reintroducing the positive condition. These effects demonstrated the interaction between heterogeneity in work productivity within a microsociety and member tolerance and intolerance of such variability under different motivational circumstances.

## GROUP COMPOSITION ANALYSES

The foregoing investigations clearly established social variables as fundamental contributors to the overall status of a confined microsociety, and they emphasized the sensitivity of such variables to a range of experimental manipulations having operational significance. Throughout such studies, mission participants were observed to seek social interaction under one set of conditions (e.g., triadic social contingencies and positive performance outcomes) and to withdraw from such interaction under other conditions (e.g., pairing social contingencies and avoidance performance outcomes). Thus, the joining and leaving of a group by mission participants under circumstances encompassing more than a single environmental condition appeared to generate social effects reflecting important dynamic processes requiring systematic experimental analysis.

Accordingly, six studies were conducted to assess the effects on individual and group behavior of a novitiate participant's introduction into and subsequent withdrawal from a previously established and stable two-person social system (Emurian, et al., 1982). The objectives of these studies were to focus upon (1) the social mechanisms and temporal properties associated with the integration of such a participant into an established crew and (2) sources of group disruption or cohesiveness fostered by his or her presence. Additionally, measures of hormonal levels based upon the collection of total urine volumes throughout the course of the studies focused upon changes in the androgen testosterone as an endocrinological index of demonstrated sensitivity to social interaction effects in both animals (Eberhart, Keverne, and Meller, 1980; Bernstein, Rose, Gordon, and Grady, 1979) and humans (Scarmemella and Brown, 1978; Elias, 1981). Such a behavioral biological analysis was implemented to provide a more comprehensive assessment of the personal and social impact generated by the introduction and withdrawal of new members with an established group (Frankenhauser, 1979).

The paradigm adopted for experimental analyses of effects of changes in group size and composition was as follows. A two-person group resided for ten successive days within the programmed environment, and members of that dyadic team operated performance tasks for their earnings. During the course of that ten-day period, a third "novitiate" participant was introduced into the programmed environment for several successive days, thereby increasing the size of the group from two to three members. A typical "introduction" period with three group members lasted four days, and it usually began on Day 4 or Day 7 of a ten-day experiment.

The rule conditions of the behavioral program that were associated with the novitiate's entrance into the group differed across successive investigations. In some studies, the novitiate received a per diem allowance, and he was not required to work for compensation, although he was permitted to contribute to the performance tasks that advantaged the two established group members. In other studies, the novitiate was required to work for compensation by competing with the two other group members for access to the single MTPB console located within the workshop. Finally, the series of investigations was undertaken with both male and female novitiates and, in some cases, with novitiates and dyadic members who had previously participated in a residential study.

In studies where the novitiate's presence primarily served as additional social stimulation for the established dyad and as a source of information regarding current events outside the laboratory, the two-person group showed a resistance to granting the novitiate permission to work, even when such work would have provided relief from operating a demanding task. Importantly, however, as the three-person condition continued over days, novitiates were observed to contribute to work productivity to a degree that was almost equivalent to the productivity of the dyadic members. Since there were no external incentives for a novitiate's work in these first introduction studies, these findings emphasized the influence of social processes alone in maintaining performance productivity at least within these cohesive group situations. Finally, novitiates showed daily urinary testosterone at the upper and lower boundaries of the standard range, but the absence of baseline levels precluded the interpretation that active social processes had governed such effects.

Transitions between two-person and three-person conditions were not always smooth in groups where the novitiate had to work the MTPB for compensation. When a novitiate forcefully intruded himself into the dyad's customary work schedule, his testosterone levels rose or fell generally in close relationship with his success or failure, respectively, to gain and maintain access to the MTPB station according to a schedule that was least disruptive to his wake-sleep cycles as determined during several baseline days preceding his introduction into the group. When sleep discipline was imposed, and when a novitiate was cooperative in negotiating an orderly sequence of using the MTPB, notable changes in testosterone were not observed in any crew participant. When a female novitiate was introduced into a two-man group, wake-sleep cycles and work periods were erratic throughout the three-person condition. Such effects were associated with the absence of notable androgen changes, even by a dyadic member who, as a novitiate in an earlier study, had successfully maintained his wake-sleep cycles and had shown a striking increase in testosterone when he joined the group.

The significance of these behavioral-biological interactions is to be understood in terms of the completeness of the resulting account of effects of the experimental variable, i.e., the introduction of a novitiate into an established group. With regard to the relevance of the endocrinological relationships observed under such conditions, it seems reasonable to suggest that the adaptive significance of any hormonal response can be best interpreted in terms of the consequences of that response at the metabolic level. Although research on the androgens has typically emphasized reproductive functions, it has been established that testosterone has potent "anabolic" properties, promoting protein synthesis in muscle and many other tissues (Dorfman and Shipley, 1956; Kochakian, 1964, 1975) and potentiating some effects of insulin on carbohydrate metabolism (Talaat, Habib, and Habib, 1957). Whether these "anabolic" effects of testosterone and the androgenic metabolites play any appreciable role in general organic or energy metabolism must, of course, await clarification by further investigative analysis. But at the very least, the present series of experiments emphasized the importance of a multidimensional analysis of the behavioral and biological interactions that determine the adaptations and adjustments of small groups in confined microsocieties.

## TEAM REPLACEMENT EFFECTS

The next series of three experiments demonstrated the extension of the research paradigm from analyses of "introduction" effects to the analysis of "replacement" effects. Whereas the previous investigations changed group size as an experimental variable or treatment, the most recently initiated studies held group size constant to evaluate effects of replacing a member of an established three-person group with a novitiate participant. The details of these replacement analyses are presented elsewhere (Emurian, et al., in press).

The replacement analyses involved important elements of continuity with the earlier studies in the manner of being systematic replications of those investigations. In a research strategy based upon systematic replications, as compared with exact or direct replications, effects of the experimental variable or treatment are demonstrated by affirming the consequent (Sidman, 1960), in which case each successive replication incrementally contributes to an understanding of effects that can be reliably attributable to the antecedent condition (e.g., introductions or replacements). The generality of the behavioral processes is assured by showing similar relationships across a broad range of circumstances (e.g., subjects, order and duration of experimental conditions, performance tasks, group size, etc.). This research strategy as adopted by the programmed environment unit has proved to be most productive and economical, especially in light of the expense and staffing effort required to undertake programmed environment investigations.

A typical replacement investigation proceeded as follows. An original three-person group resided in the programmed environment for five successive days. At the end of Day 5, one of the original crew members was withdrawn, and he was replaced by a novitiate participant who, along with the remaining two original members, formed a new team for the next five successive days. Consecutive studies differed in terms of (1) the decision rule by which an original crew member was withdrawn, (2) the number of baseline days that came before group formation, and (3) the type of performance tasks that the team members operated for compensation.

In the first replacement experiment, for example, three-person group members resided in their private rooms for a two-day baseline "alone" period during which time access to the intercom, to social activities, and to the MTPB work station was prohibited. This two-day period provided a necessary hormonal reference against which to assess endocrine responses in relationship to initial group formation. On Day 3, all activities previously prohibited were made available to the group, and each member was required to operate the MTPB for individual compensation. As in the introduction experiments, there was only one MTPB console located within the workshop, and subjects occupied the workshop singly on a self-determined rotational basis. This procedure, then, permitted an evaluation of the manner in which subjects occupied the work station (e.g., duration of work periods, time-of-day of work periods, etc.) as one of the principal dependent variables of the experiment.

At the end of Day 5, whoever of the three mission members had earned the fewest MTPB performance points, totaled across Days 3-5, was withdrawn from the experiment. This decision rule was known by the group members before the experiment began. The novitiate participant entered the programmed environment on Day 6, which was a solitary baseline day for all three subjects. On Day 7, the newly formed team had access to intercom communications, social activities, and the MTPB work station that continued to be available throughout Days 7-10. Thus, the two ten-day participants were required to adjust to the replacement of an original member, and the novitiate member was required to adjust to his entrance into an established unit whose members shared a history of having competed successfully to maintain high levels of performance effectiveness.

The results of the first two replacement analyses, which used the individual MTPB as the missions' performance requirement, emphasized the readjustments that original participants underwent when a change in team membership occurred. When a male novitiate participant replaced an original team member, wake-sleep cycles and time-of-day spent working were somewhat less stable than observed when a female subject, who had previously participated in a 10-day residential study and who had more experience than either of the original team members, replaced an original male member. That such differences were associated with interpersonal effects was indicated by the negative ratings directed toward the replacement participant by original team members in the second experiment.

The continuity of the behavioral-biological relationships observed in the "introduction" studies was demonstrated in the testosterone data from the first replacement analysis. Figure 5 shows total urinary testosterone for all subjects across successive days of that first experiment (REPL 1). The radioimmunoassay method for testosterone determinations is presented elsewhere (Emurian, et al., in press). The novitiate participant is identified as "S4." With respect to the original team members, S2 showed

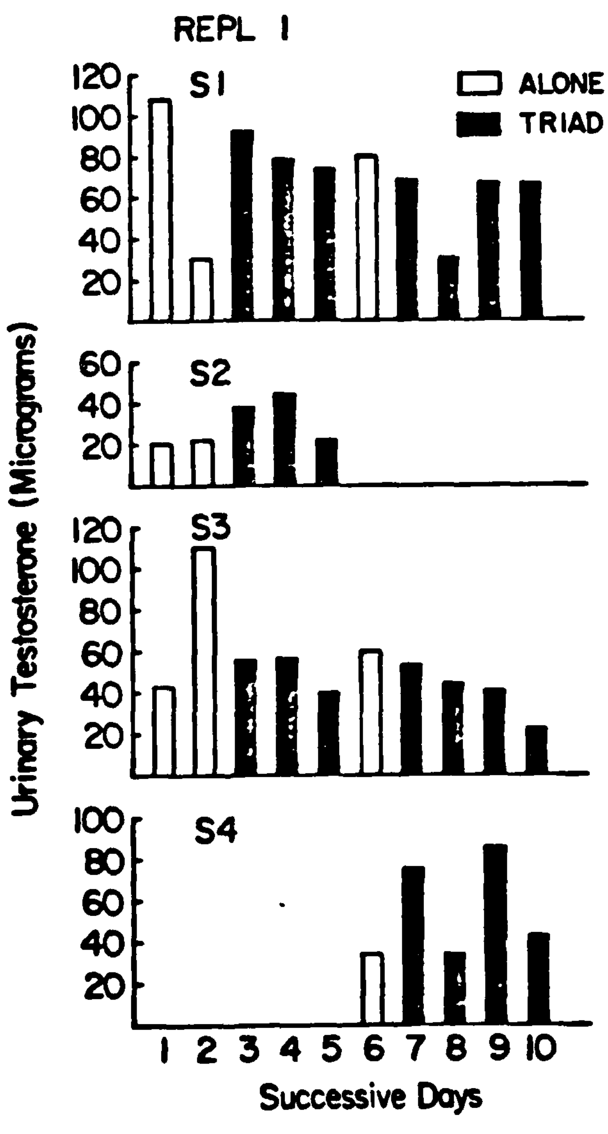



Figure 5. Total urinary testosterone for all subjects across successive days of the experiment. The novitiate participant is identified as "S4."

testosterone values that were somewhat lower than the other two participants. Importantly, these comparatively lower values were evident during the first two baseline days of the experiment. When team members commenced working on Day 3, S2's values increased somewhat over baseline levels, but they continued to be below the values exhibited by the other two members across Days 3-5. Significantly, S2 was the mission member who did not compete successfully to remain within the experiment for ten days, and he was withdrawn at the conclusion of Day 5. Finally, across Days 7-10, testosterone levels progressively declined for S3 in relationship to his shift in work and sleep times. This latter effect confirms the outcomes observed in the introduction studies, and it demonstrates, by systematic replication, the generality of the behavioral-biological processes governing such effects.

In all previous replacement investigations, the coordination required of mission participants was reflected in the sequential use of the work station and in the program synchrony necessary for subjects to meet together in the recreation room. In the third replacement investigation, however, a team performance task was introduced into the research protocol that systematically replicated the preceding analyses with a task demanding far more stringent coordination requirements.

The team performance task is an expanded version of the single-operator MTPB that previously served as the project's principal performance assessment tool. The Team MTPB (TMTPB) involves three operator consoles, each console presenting the identical display of the five task components (see Figure 3). The parameters of these tasks were modified to a difficulty level such that the concurrent inputs of three operators were required to avoid information overload and to produce maximum performance effectiveness per unit time. The "team" aspect of the task is reflected by the interlocking response demands associated with the probability monitoring subtask, and it is embedded within the context of the remaining four individually solvable subtasks. The team subtask requires the detection of a bias that was recurrently presented on any one or more of the four probability monitoring scales. Importantly, the operator inputs to the system to "correct" a bias requires each of the three operators to press the corresponding "correct" keyboard character within 0.6 sec of the first such keyboard entry. Although correction of a bias produces increments in accuracy points, a crew's failure to detect a bias results in subtractions to accumulated points. The team task, then, requires (1) processing of symbolic information (i.e., the detection of a bias), (2) sharing information by communications among team members (e.g., One operator may say "Bias on one. Ready...Go."), (3) coordination of a response (i.e., three response inputs within 0.6 sec), and (4) sustained vigilance to avoid loss. This team task reflects the major performance dimensions considered to be crucial to developing methods for quantitative analyses of the interrelationships between individual and team performance effectiveness (Turney and Cohen, 1981).

The ten-day experiment began with a three-person team whose members were new to the programmed environment and to the TMTPB. Participants had been acquainted with the individual MTPB during an orientation session, but acquisition of the TMTPB occurred for the first time on Day 1 of the experiment. For remuneration for participation, the team operated the TMTPB to a performance ceiling of 5000 accuracy points each day, requiring 6-9 hours of work to accomplish. The crew members decided among themselves the manner of distributing the performance demands of the individual and team subtasks.

At the end of Day 5, one of the three original team members was withdrawn from the experiment. Initial team members began the study with the understanding that one participant would be withdrawn, but they were not given the decision rule by which that choice would be made. At the beginning of Day 6, then, a novitiate participant was introduced into the programmed environment. To accommodate this transition, the three participants followed the behavioral program in their private quarters on Day 6, but without access to the TMTPB, intercom communications, and social activities. On Day 7, the novitiate member joined the team as the replacement participant, and this newly formed team operated the TMTPB on Days 7-10.

The results of this experiment showed that time-of-day spent working and sleeping across successive days was somewhat more stable than was the case for the preceding two replacement analyses. Three or four work periods occurred each day, and they ranged in duration from two to five hours. Although the time of day associated with team performance differed across days, work was not generally observed between 2400 and 0800 hours of a day. Sleep typically occurred during these hours, and when drift in sleep onset time was observed, all members of a team drifted in concert with each other. Finally, the pattern of work and sleep times that the initial team adopted was also observed during the final four days of the study with the reformed team.

The dynamics of the components of the individual and team subtasks differed in relationship to practice on the TMTPB and to replacement of a crew member. Initial acquisition of the individual subtasks was smooth as was reacquisition under conditions of membership turnover. In this latter regard, performance on the individual subtasks was degraded temporarily when replacement occurred despite the presence of two team members who had a combined total of almost eighty hours' practice on the TMTPB. In contrast to individual task performance, performance effectiveness on the team subtask was erratic, even though a trend toward improved team performance was apparent for initial and reformed teams.

## CONCLUSIONS

The objectives of this research project on individual and team performance effectiveness focused upon the development of principles and procedures relevant to the selection and training of mission personnel, upon the investigation of preventive monitoring and corrective procedures to enhance mission performance effectiveness, and upon the evaluation of countermeasures to the potentially disruptive effects of high-demand and stressful performance, interpersonal, and physical environments. Initial research activities were directed toward the design and development of an experimental microsociety environment for continuous residence by three-person groups of human volunteers over extended time periods under conditions that provided for programmable performance and recreational opportunities within the context of a biologically and behaviorally supportive setting. Studies were then undertaken to analyze experimentally (1) conditions that sustain group cohesion and productivity and that prevent social fragmentation and individual performance deterioration, (2) motivational effects produced by the programmed incentives maintaining individual and team performance requirements, and (3) behavioral and biological effects resulting from changes in crew size and composition. The significance of these investigative endeavors is to be understood in terms of emergent motivational, social-interaction, and group composition principles having practical relevance to the establishment and maintenance of operational mission performance effectiveness.

In this latter regard, the results obtained from these small-group studies clearly established the applicability of behavioral technologies and methodologies to the experimental analysis of individual and team performances within the context of a human microsociety. Additionally, the development of behavioral programming techniques was demonstrably effective in generating and maintaining such individual and group performances for unobtrusive monitoring and measurement with precision and regularity over time. Furthermore, the interplay between incentives both internal and external to the program provided the occasion for observations of performance in relationship to realistic incentive schedules. The application of such contingency management principles, along with the technological guidelines that provided the basis for design and development of the programmed microsociety environment, were shown to be capable of sustaining individual and team performance effectiveness and group cohesion without notable biological or behavioral disruption under conditions of spatial restriction, social separation, enforced intimacy, and high performance requirements.

More specifically, the results of these studies showed that both individual and group productivity can be enhanced under confined microsociety conditions by the application of contingency management principles to designated "high-value" component tasks embedded within the overall performance program. Similarly, group cohesiveness can be promoted, and individual social isolation and/or alienation (*i.e.*, group fragmentation) can be prevented by the application of contingency management principles to social-interaction segments of the performance program.

Conditions that were found to result in progressive deterioration of individual and team performance effectiveness included aversive motivational contingencies. The by-products of aversive schedules that emerged under such circumstances were found to be quantifiable in measures of verbal performance (*e.g.*, behavioral program ratings), interpersonal performance (*e.g.*, verbal confrontation and aggression), work performance (*e.g.*, diminished productivity), and crew morale (*e.g.*, irritability and dysphoric mood). In contrast, positive incentive schedules effectively counteracted the disruptive consequences of aversive contingencies while at the same time supporting high work productivity free from negative side-effects.

Related research results emphasized the prominent involvement of behavioral and biological processes that were functionally related to adjustments and reactions when changes occurred in group size and team composition. The experimental analysis of such "introduction" and "replacement" effects emphasized the critical importance of providing a structured transition in the form of orientation and training regimens for both novitiate and established team participants to minimize potentially disruptive effects of altering the interpersonal and social dynamics of a confined microsociety.

The development of the Team Multiple Task Performance Battery (TMTPB) opened an important dimension to this ongoing research program. By imposing task requirements involving coordinated responses among team members, the analysis of the dynamic interplay between individual and team performance effectiveness was initiated within the context of ongoing "replacement" investigations. For example, it was found that the replacement of an established team member by a novitiate participant resulted in degraded performance on the individual subtasks of the TMTPB and in a shift in the operation of the team subtask itself. These findings suggest that a novitiate's lack of experience and skill on critical aspects of a task requiring coordination could be masked by experienced team participants who were perhaps unwilling to tolerate even a temporary degradation in overall team performance effectiveness. By developing methods to detect and quantify the relative contributions of individual members to the operation of the team task, intervention guidelines or pre-training schedules could be investigated that would ensure the most effective balance between individual and team performance effectiveness and subtask proficiency under the various conditions of membership turnover.

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# FOOTNOTES

1. Multivariate analyses were conducted by R.L. Ray, Assistant Professor of Behavioral Biology on the unit. Endocrine analyses were conducted by James L. Meyerhoff and Edward H. Mougey, Walter Reed Army Institute of Research, Washington, D.C. Operational aspects of the research laboratory are coordinated and administered by Ann Rutledge. Jerry Locklee is the principal supervisor of ongoing investigations, and June Hitt assists with the many details associated with a study's successful completion. Electrical engineering and computer sciences input is provided by Dave Krausman along with Rick Wurster, Ron Atkinson, and Leonard Daley. The following individuals have assisted in monitoring the conduct of experiments during the past two years: Richard Bodek, Anne Campbell, Kathleen Connors, Osbert Cush, Timothy Doyle, Greta Goodman, Ted Green, Michael Hall, Greg Hradsky, Thomas Kravitz, Vincent Matanoski, William McDowell, Anthony Olsen, Larry Park, Michael Plasay, Merle Pokempner, Fred Rutledge, Judith Samkoff, Keith Slifer, and Betty Ward. Margaret J. Nellis is a Post-Doctoral Fellow on the unit. The behavioral program and the methods adopted for its implementation were designed and operationally proven in collaboration with Cleeve S. Emurian.

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